(12) # EUROPEAN PATENT APPLICATION

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(54) **Process and device in respect of a three-dimensional body usable in the human body.**

(57) Input data (ID) representative of a model are stored in a computer installation (ST) in memory cells (DF1). The data-processing equipment operates with a program which is directed, by means of first signals (i1) generated by one or more first activations of terminal members (TER'), to generate, with the aid of the said input data, representations of the surface of the body in the form of contours of a number of vertical sections extending through the centre axis of the body. The contours are presented one at a time on the screen of the computer installation. By means of second signals (i2), the said program is directed to simulate on the cross-sections/contours concerned an alteration or extension attributable to a variant of the model. With third signals (i3), the program is directed to store in memory cells (DF2) data attributable to the variant simulated by means of the altered or extended vertical sections. The latter data form or are utilized to generate output data (UD) from the installation (ST).

It is proposed that Figure 6 should accompany the abstract.

Fig. 2

EP 0 643 948 A1
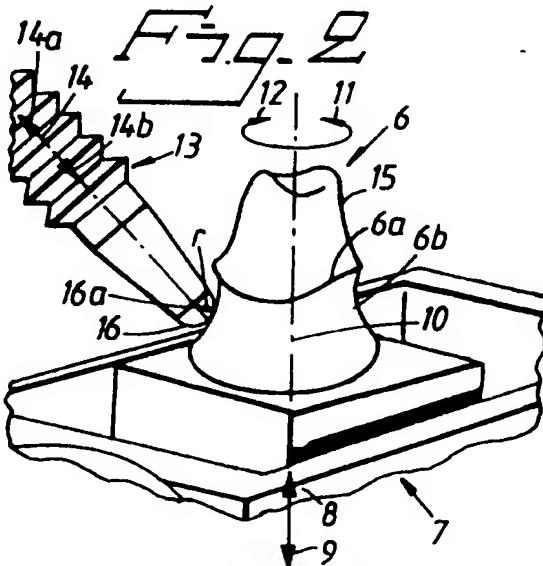
TECHNICAL FIELD

The present invention relates to a process for achieving, by means of input data representing a three-dimensional body usable in the human body, output data which can be used for manufacturing purposes and represent an altered or extended variant of the body. As an example of the said three-dimensional body, a tooth sleeve, dental bridge or other dental structure can be mentioned. The said input data are fed to a computer installation from which the said output data can be extracted in dependence upon the input data. The computer installation exhibits a computer screen and operates with a CADD-program (Computer Aided Dental Design). The program derives from principles for CAD-programs (Computer Aided Design) and has been adapted for the said functions and fields of application. With the aid of the said program, an alteration or extension attributable to the body variant relative to the three-dimensional body can be simulated. Also included are terminal members, by means of which the alteration or extension in question is effected. The invention relates also to a device for realizing the said process.

PRIOR ART

By virtue of Swedish patent 9003967-8 (468 198), it is previously known to utilize computer-aided manufacture of dental and other products usable in the human body. The known equipment proposes purely general usage of computer-aided equipment, in which particular alterations and extensions can be attached to a model, in question or to fed-in data representing a model and design measures relating to the product in question can be taken with the aid of attached input data.

In the case of conventional manual formulation of tooth sleeves, tooth crowns, etc., the dentist/dental technician formulated the model in question which was dispatched to the manufacturer. When the dentist/dental technician received the model back, adjustments were made to it and sent back to the manufacturer, etc., until a product offering approved results was obtained.

Readings of three-dimensional bodies normally involve large quantities of data. Various measures have been proposed for keeping these data quantities down.

DISCLOSURE OF THE INVENTION

TECHNICAL PROBLEM

There is a need to be able to formulate more exact models at the practice of the dentist/dental technician. The object of the present invention is to solve these problems and to propose a tool or aid for highly advanced, on-site model production or model copying.

There is also a need for the model to be able to remain at the practice so as to be able to be used privately and to avoid the model or equivalent being dispatched to the manufacturer by post, courier, etc. The invention solves this problem also by making it possible for only data relating to the shaping of the model to have to be dispatched to the manufacturer via modem, diskette, etc.

The invention proposes the utilization of computer-aided equipment, which is normally a new instrument for currently practising dentists/dental technicians. It is therefore important that the tools or aids should be able to operate with simple handling principles and routines. The invention solves these problems.

The manufacturing accuracy in products of this type must be kept high, e.g. $\pm$ 10 μm, in order to be able to function well when fitted to a patient. Such accuracy can entail machine accuracies and computing accuracies of $\pm$ 0.0015 mm. The design or formulation of tooth sleeves, dental bridges, etc., must therefore be able to be carried out with great precision and clarity. The output data which are produced and which will serve as a basis for milling and other machining coordinates must be accurate. The invention solves this problem.

In this type of computer-aided design, certain features are included which can be practised and realized only by dentally skilled staff who will be able to apply their professional expertise in the model formulation phase. The latter must be able to be effected without any complication of the handling procedures and equipment. The invention solves this problem.

There is a need to be able to reduce the contributions made by the dentist/dental technician in connection with the formulation of tooth sleeves, dental bridges, etc. The invention largely solves this problem and permits routines in which repeated dealings with the product in question can be eliminated. The dentist/dental technician can make a clear contribution and does not need to feel his/her way along in successive stages. The dentist/dental technician can easily influence the shape in the copying process, as well as when checking patient-matching. He/she can optimally utilize available spaces for cement and modifications. Accurate adjustments can be made to the interface between the sleeve/bridge and tooth remnants, jawbone, etc.

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In connection with computer-aided copying of a dental product, it has been shown that the identification of the preparation line on the computer screen runs up against problems. The invention solves this problem and offers aids to enable the dentist/dental technician to fix the preparation line in the output data with great accuracy.

In the formulation of models and products in the form of tooth sleeves, it is essential and crucial to the entire production that the angling of the sleeve material at the preparation line (the end edge of the shell) or preparation boundary can be made exact. The angling should be effected, moreover, in dependence upon the position on the tooth, i.e. a first angle should be obtained on the outer side of the tooth and a second angle on the inner side of the tooth, etc. This applies also to the bulges of the tooth/model on the inner and outer sides, etc. The invention solves this problem and proposes the utilization of macro models (with algorithms/rules) for various basic forms of teeth, which macro models are afforded influence upon the respective model copying, i.e. if the product in question relates to the use of a certain type of tooth, the macro model of this tooth is applied to the product in question.

Shapings of the teeth also vary within broad limits. Characteristic special features can nevertheless be traced in the different basic forms, namely eye-tooth, front tooth, milk tooth, etc. According to the inventive concept, the characteristic special features should be able to be documented and utilized in the copying and production of the respective product. The invention solves this problem also and proposes utilization of a library in which characteristics of basic forms are stored in the ongoing copying and manufacturing production. As produced products are tested on and used by patients, experiences from the trials and usages can be fed back to the system and the characteristics gradually perfected. The system can also be made self-teaching insofar as it accepts only the optimal product in overall terms.

Teeth, models, etc. are largely individual and scanning of three-dimensional bodies of this type normally requires large data quantities to be handled and there is a need to be able to reduce these data quantities and nevertheless achieve the sought-after precision in copying and production of the products in question. The invention solves this problem also and enables the copying and manufacturing times to be reduced using the same compared computing power. From the software viewpoint, the preparation time for milling coordinates of a sleeve, for example, can be realized according to the invention in as short a time as about 50 sec. using a computing power which is found in conventional personal computers currently sold on the market.

SOLUTION

In accordance with the new process according to the invention, one of the characteristics of the process is that the said input data are read and stored by the computer installation in memory cells and that the said program is directed, by means of first signals generated by one or more first activations of the terminal members, to generate, with the aid of the said input data, representations of the surface of the body in the form of contours of a number of vertical sections extending through the centre axis of the body. The contours are here presented one at a time on the screen. The process is also characterized in that the CADD-program is directed, by means of second signals generated by one or more second activations of the terminal members, to simulate on the cross-sections/contours concerned an alteration or extension attributable to the body variant. The process is finally characterized in that the program is directed, by means of third signals generated by one or more third activations of the terminal members, to store in memory cells data attributable to the body variant simulated by means of the altered or extended vertical sections. The latter data form or are utilized to generate the said output data.

In one embodiment, the input data are related to information acquired from a system of coordinates in which the body is installed. The system of coordinates in question requires two predictably movable parameters and one unpredictably variable parameter. This system of coordinates is utilized throughout the manufacturing system, i.e. in the reading function, the copying function and the manufacturing function. The input data are disposed in one or more first data files and, following copying by means of the computer installation, the output data are disposed in one or more second data files having the same or equivalent format as the respective first data file. In the event of alteration or extension to a cross-section/contour which is controlled by means of the said second signals, a reaction takes place according to a control system which is utilized by the program and pays regard to one or more factors. Examples of such factors can be tooth type, front and rear of the tooth in question, the height of the respective tooth, bulging or bulges of the respective tooth, angle/angles at the preparation line, etc.

In a further embodiment, the CADD-program is directed, by means of fourth signals generated by one or more fourth activations of the terminal members, to represent a displaceable horizontal line which, in dependence upon the said fourth activations, is controllable in the vertical direction of the vertical sections/contours. Upon displacement of the horizontal line to a part of the respective vertical section or contour representing the

preparation line of the body, a line, e.g. a line represented by dots, is generated by the program and presented on the screen. The latter line therefore represents the preparation line of the body when the three-dimensional body is spread out on a flat surface. Data relating to the preparation line representation form part of the said output data.

In one embodiment, a library is utilized for the saving of data files and macro models attributable to various basic types of teeth, e.g. eye-tooth, front tooth, milk tooth, etc. Data in the said data files are utilized in the copying of each subsequent model or equivalent. Use is made of the knowledge, acquired by experience, of whether previous creations or copyings have satisfied the requirements or not. Comparison-making members are actuated or activated to conduct a comparison between a body variant currently under formulation and previously formulated body variants. The library function can be performed using a register utilizing a self-teaching function, statistics from which the dental technician receives help in his product formulation. Optimal shapes for the various tooth types are implemented in the equipment and the total number of body variants created in the equipment can be utilized, as well as any experience-based information supplied by practising dentists/dental technicians. A number of macro models can further be utilized. The macro models are attributable to rules and mathematics linked to various basic functions in the copying and production. Basic functions of this type can be the basic forms of the teeth, the creation of a base surface, consideration of the tooth type, formulation of vertical and circular sections/contours of the respective body variant/tooth, alteration of the height of the tooth in various vertical sections, bulging of the inner and outer sides of the tooth, thickness of a utilized tooth sleeve, etc.

In one embodiment, the equipment is utilized for the formulation of tooth sleeves. By means of fifth signals generated by one or more fifth activations of the terminal members, an item of shell-thickness information is attached to a respective vertical section or contour, so that a shell is presented on the screen based on the respective vertical section/contour. With sixth signals generated by sixth activations of the terminal members, the connection angles of the respective vertical section of the shell can also be influenced. The connection angle is situated at the preparation line and relates to the shaping of the connecting surface/connecting lip against a tooth remnant, mouth cavity, jaw, etc. in question.

A device exhibiting the special features characteristic of the invention is principally characterized in that it forms a station which can be set up at the practice of a dentist/dental technician or equivalent professional category and by means of which the body variant can be simulated by means of a CADD-program or CADD-function formulated for the purpose. The station here comprises memory storage cells for the input data. The CADD-function is arranged so as to reproduce the surface of the body on the screen and to permit an alteration or extension of the latter according to the body variant to operate with a number of vertical sections, extending through the centre axis of the body, of the body contour or body variant contour. There is therefore a two-dimensional representation of the read or manufacturable three-dimensional body. The vertical sections (= the two-dimensional representations) can be represented on the screen one at a time, and attachable alterations or extensions related to the alteration or extension of the body variant relative to the body can also be formulated on the screen. Memory cells, which can be constituted by the above memory cells or by additional memory cells, are arranged to receive and store data attributable to the altered or extended vertical sections/contours, which data form or serve as a basis for the said output data.

ADVANTAGES

By virtue of the above proposals, an effectively functioning tool or aid is obtained for the practising dentist/dental technician or equivalent person within a different professional category for treatment of the human body. The copying function can be constituted with great precision and the aid saves time for the dentist/dental technician, who is able to simplify his/her routines in the production of dental products. Although the station in question is separated from the manufacturing function, the high accuracy can be maintained throughout the system. The handling of the equipment in question does not require a higher degree of specialization amongst the staff involved. This should be compared with the staff at a general CAD-station, for example an auto-CAD station, which has to be operated by prominent experts. The two-dimensional representation allows substantial interaction between humans and the computer installation. The handiwork which is practised by the dental technician remains, and more complicated shapes and preparations can be managed. Control over machinery manufacture can be obtained at an early stage on the screen. Follow-up work is reduced or eliminated completely.

DESCRIPTION OF THE FIGURES

A presently proposed embodiment of a process and a device according to the invention will be described

below with simultaneous reference to appended drawings, in which:

Figure 1   shows a personal computer which can be used for the copying function, in perspective section from above,

Figure 2   shows the installation of the model in a system of coordinates and a scanning function for the generation of input data, in perspective section from above,

Figures 3-4   show examples of various shapings of a copied product, in vertical section,

Figure 5   shows a contour of a model during copying and the effect produced during the copying, in vertical section,

Figures 6-7   show examples of the functional structure of the computer installation, in basic diagram form/block diagram form,

Figures 8-10   show the fixing of the preparation line on a model, in diagram form,

Figure 11   shows a menu on the computer installation according to Figure 1, which menu relates to the application of shell thickness and angle at the preparation line to a contour or a vertical section,

Figure 12   shows the representation of a shell on the visual display unit, in vertical section,

Figures 13-15   show three different examples of the angle at the end of the shell in connection with the preparation line, and

Figure 16   shows a finished preparation having a macro model represented on the screen, in vertical section.

DETAILED EMBODIMENT

In Figure 1, a computer installation is denoted by 1. The computer installation can be constituted by a personal computer, e.g. an IBM-compatible personal computer having a type 386 or type 486 processor. The operating system can be constituted by DOS 5.0 type or higher and the internal memory capacity should be at least 2 MB. The computer can expediently be provided with a "mouse" function 2. A keyboard terminal 3 having terminal members 4 should additionally be included. The computer installation is preferably provided with a colour screen 5 and can have an extra I/O card, as it is known. In addition, the computer can comprise a modem which can be integrated in the computer or can constitute a separate unit. The modem is preferably Hayes-compatible and is arranged so as to communicate with a manufacturer via the telecommunications network (the public telecommunications network). For the communications, standard programs can be used, e.g. a Commute 2.0 program from Central Point, which are included with the software.

The computer installation also operates with a CADD-program which is built on the same principles as conventional CAD-programs, but has been adapted and perfected for dental copying and production. The adaptation of standardized CAD-functions has been carried out as described below.

In Figure 2, a model manufactured by a dentist/dental technician is denoted by 6. The model is aligned in a fixture 7. The fixture, in turn, is disposed on or in a rotary holder, which can additionally be raised and lowered in the directions of the arrows 8 and 9, these coinciding with the direction of the centre axis 10 of the model. The model is rotated around the said centre axis in the directions of the arrows 11 and 12. The model is turned and vertically displaced, therefore, relative to a scanning device 13, which is longitudinally displaceable along its centre line 14, but is otherwise fixedly disposed relative to the rotating and rising or sinking model. The model is rotated, during scanning, at 40-100, preferably 50-70 revolutions per minute. The rise for the vertical movement of the model during the rotation can be 0.1-0.4 mm per revolution. The scanning device 13 therefore comes to track the contour 15 of the model. The scanning device exhibits a spherical front surface or probe 16, which is physically brought to bear against the surface in the present case. The scanning device operates with great precision as regards the scanning function. The body is scanned, for example, 360 times per revolution, i.e. scanning takes place at each degree of turn.

In accordance with Figures 3 and 4, differently shaped tooth sleeves 17 and 18, respectively, will be able to be copied or produced, based on the said scanning according to Figure 2. The CADD-function in the computer installation can represent and reproduce contours or vertical sections of the acquired input data from the scanning according to Figure 2. To the shown contour, a shell thickness t can be applied, which will be valid for the sleeve in question. The sleeve will constitute a building block for a utilized tooth material 19 and 20 respectively, e.g. in the form of plastic, titanium, ceramic, etc. The formulation facility on the screen enables the dental technician/dentist to experiment away on a visual model and "construct" an optimal tooth 21 and 22 respectively. In comparing the figures, it is apparent that the thickness can be given various variations along the extents of the shell 17 and 18, respectively, in the peripheral direction and/or vertical direction(s). The shell 18 according to Figure 4 thus contains a thickening 23, which is not evident from the embodiment according to Figure 3. The thickness of the shell can further be varied around the periphery of the model or copy, and

the height H of the thickness 23 according to Figure 4 can thus be varied around the periphery, etc.

The CADD-programs operate with representation of vertical sections one by one in accordance with Figure 5, which thus shows a vertical section or contour 24 extending through the centre axis 10 according to Figure 2. In known fashion, the contour in question can be varied in size, cf. contours 25 and 26. The surface of the model 6 (see Figure 2) can thus be represented on the screen by the depiction of, for example, 360 vertical sections/contours through the centre axis 10. The terminal members 3 according to Figure 1 can be actuated to show the said vertical sections one by one on the screen and to advance the various vertical sections or contours in a specific or non-specific order.

Figures 6 and 7 show examples of the structure of the computer installation. This comprises a CPU of the above-specified type.

A RAM working memory and a hard disk HD are additionally included. The equipment forms a station which can be set up at the place of work of the dentist/dental technician and which can possibly be coordinated with a reading function (not specifically shown here) of models (preparation models). The station has the designation ST. Also forming part of the computer installation is the abovementioned terminal TER. Matching circuits AP1 and AP2 are also included. Via the matching circuit AP1, input data ID are received according to the above. Via the matching unit AP2, output data UD can be dispatched.

According to Figure 7, the hard disk HD according to Figure 6 comprises memory space DF1 and DF2 for data files for input and output data respectively. Additionally included are a macro model library MB and a data file library DB. The hard disk comprises a matching circuit ANP3, which connects the hard disk HD by a bus connection BF to units corresponding to others mentioned above. Also included is a comparison-making member JF, which is described more closely below. The bus connection can be arranged for 32 or 64 bits. In order to raise the speed of the equipment, the RAM-memory is utilized at full capacity.

The input data ID are received and stored in a first data file DF1' and the data, output data, to be dispatched from the equipment are disposed correspondingly in a second data file DF2'. The various files have an equivalent format.

A number of signals generated by means of the actuating members TER' on the terminal TER are shown in Figure 6. The terminal has three parallel connections to the bus so as to offer an illustration of the said signals. By means of first signals i1 generated by one or more first activations of the terminal members TER', the CADD-program is directed to generate, with the aid of the said input data in the data file DF1', representations of the surface of the body in the form of contours of a number of vertical sections extending through the centre axis of the body, cf. Figure 5. By means of second signals i2 generated by one or more second activations of the terminal members, the program is actuated to simulate on the cross-sections/contours concerned an alteration or extension comparable to the body variant, cf. Figures 3, 4 and 12. By means of third signals i3 generated by one or more third activations of the terminal members, the program is directed to store in memory cells DF2 data attributable to that body variant simulated by means of the altered or built-on vertical sections. The said data can form or serve as a basis for the said output data. By means of fourth signals generated by one or more fourth activations of the terminal members, the program is directed to represent a horizontal line, cf. Figures 8, 9 and 10, which horizontal line, in dependence upon the said fourth activations, is controllable in the vertical direction of the vertical sections, as described below. By means of fifth signals i5 and sixth signals i6, the program is directed to attach to a respective vertical section or contour an item of shell-thickness information, so that a shell is presented on the screen for a respective vertical section/contour, cf. Figure 12, or to actuate a connection angle on a respective vertical section, cf. Figures 13-15.

The hard disk also comprises storage spaces or a library for the saving of macro models and data files which are attributable to different basic types of preparations and teeth, e.g. eye-tooth, front tooth, etc. According to the above, the said saved information serves as a basis for future creations of subsequent simulations and body variant formulations. Characteristic information is stored and can be influenced by acquired experiences of how patients feel about produced products. Information is fed back to the system, e.g. via the terminal TER, by practising dental technicians/dentists, scientists, etc. The library can be configured having a self-learning function of a type which is known per se, which self-learning function means that the said characteristics are constantly being perfected. The said characteristics are applied to a respective model, tooth, etc. currently undergoing copying and model formulation. The preparation boundary on the model can therefore be adapted to the respective tooth type, as well as bulges, heights, extents in the horizontal direction, etc. The implementation can be effected in a manner which is known per se, using program-based measures.

In Figures 2 and 5, a preparation line 6a and 6a' respectively is indicated on the model. The model should be configured such that the preparation line remains clear, which can be realized by means of the arrangement of a recess or indentation 6b below the preparation line. The fixing of the preparation line is a special skill which is practised by the dental technician/dentist. In order to incorporate data relating to the preparation line into the said output data from the computer installation, the process according to Figures 8, 9 and 10 is utilized. A

horizontal line 27 is arranged such that it is displaceable in the vertical direction of the screen by means of the terminal members and the CADD-program. Figures 8, 9 and 10 show various vertical positions of the horizontal line. In the figures, the contour 24' has additionally been enlarged in connection with the position of the preparation line or preparation boundary 6a". The line is installed with the aid of the terminal members (keys, mouse, recording members and similar members), so that it intersects the preparation line 6a" in the section according to Figure 8. A line 28 represents the preparation line on the various vertical sections or contours. A vertical line 29 shows the position of the vertical section in question relative to the line. Each section can be represented, in the line 28, by a dot, and it can be seen from Figure 8 that a number of vertical sections have been represented by a number of dots. The representation of the preparation line according to the vertical section in Figure 8 will thus be deposited at the line 29, which can therefore be realized with the aid of the terminal members, etc. Figures 9 and 10 show other sections, and the line 28 shows how the fixing of the preparation line has progressed.

In greater detail, the process proceeds with the operator starting from the main menu in the user program. The data file in question is marked by the use of a band of light at the top the screen. "CADD" is selected from the main menu and, by further actuation of the keys, the data file can be installed in the working memory. The CADD-program is started up and the preparation model is represented, according to Figure 5, on the screen. The image is enlarged in accordance with Figures 8, 9 and 10. The horizontal line can be adjusted on the profiled edge 6a" in question, where the dental technician or dentist judges from experience that the preparation line goes. The markings are realized with the line 28. After this, the computer accomplishes the formulation of a subsequent profile, etc. The number of scannings in a respective revolution can total, for example, 36, i.e. every tenth degree. The curve between the dots is interpolated in known fashion, e.g. Lagranges/interpolation formula, Cubic's spine, etc. Following the formulation of the complete line 28, assessments can be made of whether the line correctly reproduces the preparation line. The latter should assume a uniformly soft shaping without any sharp portions or edges. If Figure 9 is considered, for example, it can be seen that at 28a there is a sharp deviation of this kind. This should very probably be rectified. This can be realized by the vertical section in question being re-formulated on the screen and a new estimate being made of the preparation line in respect of the particular vertical section. The scale 30 can here be utilized together with the vertical line 29.

In accordance with the above, the preparation model is rotated slowly whilst scanning proceeds by way of the scanning unit, so that the surface of the model is read along a spiral-shaped line which starts below the preparation line and ends directly above the model. The normal-sized tooth/model which is thus described can be described by a data quantity comprising about 20,000 measurements, which is regarded as a relatively small quantity and allows effective handling in the copying function. The data program transforms the measuring points into a surface, which is converted into a large quantity of vertical sections or contours. The profile of the preparation model can thereby be studied from all angles. The alterations and extensions to the various vertical sections form the basis for the copying function.

The macro and macro models are utilized as described below. A macro is herein constituted by a macro model plus parameter information relating to the shell or sleeve shaping, the angle at the edge or lip of the shell or sleeve, the vertical position of the supporting edge of the shell or sleeve on the tooth remnant, etc. The respective macro model constitutes a mathematical model which can be integrated or superimposed on the visual display unit with, for example, information (graphs) attributable to the shell/shape of the shell. The respective macro model is attributable to a tooth type (e.g. milk tooth, eye-tooth, etc.), preparation form, etc. The respective macro model is stored in an assigned data file which is filed in a library from which the macro models can be selected by means of terminal members, in a manner which is known per se, by means of the command (the macro name is entered by means of the terminal members in known fashion. Icons, too, can be utilized for the formulation). Correspondingly, different files for read data and calculated data can be arranged for different tooth shapes, preparation shapes, etc. The files can be run together for formulation of desired shapes, so-called "unions", on the visual display unit, by means of which unions options are provided on the screen for the formulation of simultaneous graphic representations. Read data can here be attributable to inner surfaces, outer surfaces, etc. Also, bodies and shapes can be formulated for free merging on the screen (cf. "morphing", as it is known). The files can thereby be merged and different parts of the contours mutually exchanged. This process enables an inner surface file and read wax-hood file, for example, to be merged and tied to a macro model. The manual work which is input in this way can be computer-processed, which opens the way for accuracy in difficult preparation cases/shapes. High accuracy of fit can be obtained, and the handiwork can be maintained by virtue of the computer control having to be managed by a dental technician. The formulated product does not need to be treated.

The dental technician/dentist is therefore able, in the case involving macro models, to select desired macro models from the library and attach these to graphic representations of shell or sleeve profiles which are formulated on the computer screen in question. The dental technician/dentist is also able to choose shell thickness

and sizes of the preparation angles and thereby create extensions, alterations, adaptations, etc., in the originally formulated graphic representation of the shell/sleeve. Those shapes of tooth creations in question which have been worked out in advance and obtained by experience yield major advantages. The advantages relate, inter alia, to handling. The interaction between humans and the computer can be substantially reduced, e.g. when compared with a conventional CAD-function in which the interaction is extensive in the formulation of three-dimensional bodies.

The read data/files can be attributable to the final shape of the tooth and the current shape of the tooth remnant. By running together and superimposing the information, optimal solutions of the shaping of the supporting body, here referred to as "union", can be achieved. The structure of the shell or sleeve can also be adapted according to the properties of the extension material, which material can be constituted by, for example, porcelain. Choice of colour can also constitute a parameter in this context. References to the preparation line can also serve as a basis for the structure.

A copied model of the model according to Figure 2 can be realized. Figure 11 shows a menu in which it is possible to construct a shell 31 according to Figure 12. The menus can therefore comprise "shell thickness" and, by selection of a keyboard option, a desired thickness, e.g. 400 micrometres (0.4 mm), can be chosen. In Figure 12, the thickness is indicated by t'. Using the same menu, an angle can also be chosen at which the copy connects with a preparation line, cf. Figures 13, 14 and 15, which are represented exhibiting files containing macro model, shell and angle. The latter figures show the angles 0°, 20° and 40° respectively. The angles, thickness etc. are or can be dependent upon tooth type (eye-tooth, milk tooth, etc.). The angles in question can be connected, in copying, to the preparation line and optionally chosen from 0° to 40°, starting from a vertical line. This too is stored as macro models in data files and automatically follows the data file. If an angle other than 0° is desired, this can be marked on the menu according to Figure 11 by indicating the number of degrees in the angle function. This can be realized in connection with the indication of the shell thickness, which can itself be altered correspondingly.

The said angles relate to the angles between the free end surface 31b, 31b', 31b" of the shell and a vertical line. The depression 31a, 31a',31a" above the boundary surfaces is dependent upon the said angles and can be effected (represented) with the aid of macro models.

In Figure 16, a graphic representation, on the computer screen, of a contour or vertical section of a read surface (inner surface in the representation) is shown by 32. The reading is stored in a first file. On the representation, a shell 33 has been attached, which shell has been realized using a macro model in the program, which macro model may have been acquired from a second file. The outer surface of the shell has been indicated by 34. The thickness of the shell 33 can be chosen according to the above. In addition, from the macro model library, a macro model representation 35 has been fetched from a third file (by the operator). By formulating different macro models and superimposing this on the shell representation and by working with different shell thicknesses, edge angles at the preparation boundary and/or other parameters such as the defined height of the relief edge on the tooth remnant, the operator (dental technician) is able to effect alterations, adaptations, extensions, etc. to be supplied to the supporting structure (the shell, sleeve, etc.) The adaptation is preferably made with regard to material in the sleeve (e.g. titanium) and the particular extension material 36 (porcelain or other material). Colour, appearance, etc., can here be included as parameters.

Output data according to the above and which constitute the end result of the copying and designing can be disposed in a data file which is dispatched to the manufacturer. The data files of incoming and outbound data are preferably configured in the same format. According to the above, the outbound data file is dispatched by modem, via the public telecommunications network, according to the above.

A number of basic types of macro models can be utilized in the program in question. A macro model can thus be utilized for the limiting angle function, shell thickness function, edge extent function and edge top function. In addition, the angle function for a recess 6b can be included as a macro model, as are the angle of curvature functions in respect of the said preparation line. The system of coordinates (preferably polar) which is utilized jointly for model reading and manufacture operates with two predictably movable or "locked" parameters and an unpredictably variable or non-"locked" parameter. The one of the said former parameters is constituted by the said rotary movement of the model 6 according to Figure 2, which rotary movement is 11 or 12 and can, for example, be constant or vary in a predefined manner. The other predictable or "locked" parameter is constituted, in the case according to Figure 2, by the constant displacement of the model in the directions 8 or 9, coinciding with the centre axis 10. The unpredictable parameter is constituted, in the case according to Figure 2, by longitudinal displacement movements of the scanning member 13 along the longitudinal axis 14, which are caused by the shaping of the contour 15. A fourth parameter, which is itself predictable, might be the radius of the scanning probe in question.

The invention is not limited to the embodiment shown by way of example above, but can be subject to modifications within the scope of the subsequent patent claims and the inventive concept.

Claims

1. Process for achieving, by means of input data (ID) representing a three-dimensional body (6) usable in the human body, e.g. tooth sleeve, dental bridge or other dental structure, output data (UD) which can be used for manufacturing purposes and represent an altered or extended variant of the body, here referred to as the body variant, which input and output data can be fed to or extracted from a computer installation (1) which exhibits a computer screen (5), operates with a program by means of which an alteration or extension attributable to the body variant can be simulated, and has terminal members (3) (key set, mouse, etc.), by means of which the alteration or extension is effected, characterized in that the input data are read and stored by the computer installation in memory cells (DF1), in that the said program is constituted by a CADD-program and is directed, by means of first signals (i1) generated by one or more first activations of the terminal members (3), to generate, with the aid of the said input data, representations of the surface of the body in the form of contours (24, 24') of a number of vertical sections extending through the centre axis (10) of the body, which contours are presented one at a time on the screen (5), in that the said program is directed, by means of second signals generated by one or more second activations of the terminal members, to simulate on the cross-sections/contours concerned an alteration or extension attributable to the body variant, and in that the program is directed, by means of third signals (i3) generated by one or more third activations of the terminal members, to store in memory cells (DF2) data attributable to the body variant simulated by means of the altered or extended vertical sections, which latter data form or are utilized to generate the said output data (UD).

2. Process according to Patent Claim 1, characterized in that the input data are related to information from a system of coordinates in which the body is installed and in which the system of coordinates requires two predictably movable parameters (8, 9 and 11, 12) and one unpredictably variable parameter (14a, 14b).

3. Process according to Patent Claim 1 or 2, characterized in that the input data (ID) are disposed in a first data file (DF1) and the output data are disposed in a second data file (DF2') having the same or equivalent format as the first data file.

4. Device [sic] according to Patent Claim 1, 2 or 3, characterized in that in the event of alteration (23) or extension to a cross-section which is controlled by means of the said second signals, a reaction takes place according to a control system which is utilized by the program and pays regard to one or more factors or parameters, e.g. tooth type, front and rear of the tooth in question, tooth height, bulging, angle at the preparation line, preparation shapings, etc.

5. Process according to any one of the preceding patent claims, characterized in that the program is directed, by means of fourth signals (i4) generated by one or more fourth activations of the terminal members or an associated mouse, to represent a displaceable unit, e.g. a horizontal line (28), which, in dependence upon the said fourth activations, is controllable in the vertical direction of the vertical sections, in that, upon displacement of the unit to a part (6a'') of the respective vertical section representing the preparation line of the body, a line, e.g. a line represented by dots, is generated by the program and presented on the screen (5), which latter line therefore represents the preparation line of the body when the three-dimensional body is applied to a flat surface, and in that data relating to the said preparation line representation (28) form part of the said output data.

6. Process according to any one of the preceding patent claims, characterized in that a library (DB) is arranged for the saving of data files attributable to various basic types of teeth, e.g. eye-tooth, front tooth, milk tooth, etc., and other variables, such as, for example, strength, facade material, etc., and in that data, e.g. continuously fed-in data, which are entered under the library function into the said data files are utilized in the creation of each subsequent simulation and body variant formulation such that use can be made of the knowledge, acquired by experience, of whether previous creations have satisfied the requirements or not, and in that comparison-making members (JF) are actuated or activated to conduct comparisons between a body variant currently under formulation and previously formulated body variants.

7. Process according to Patent Claim 6, characterized in that the library function (DB, MB) can be performed using a self-teaching function, and in that the optimal shape for the tooth type in question is based upon the total number of body variants created in the equipment and possibly upon experience-based information supplied from outside.

8. Process according to any one of the preceding patent claims, characterized in that a number of macro models, which are attained by calculation, experience, etc. and can be arranged in a designated library (MB), are utilized, which macro models utilize rules/mathematics linked, for example, to basic forms of the teeth, the creation of a base type, tooth type, formulation of vertical and circular sections of the respective body variant/tooth, alteration of the height of the tooth in various vertical sections, bulging of the inner and outer sides of the tooth, thickness of a utilized tooth sleeve, etc.

9. Process according to any one of the preceding patent claims, characterized in that the program is directed, by means of fifth signals (i5) generated by one or more fifth activations of the terminal members (TER') or an associated mouse function, to attach to a respective vertical section or contour (24, 24') an item of shell-thickness information (t), so that a shell is presented on the screen for a respective vertical section/contour.

10. Process according to any one of the preceding patent claims, characterized in that the program is directed, by means of sixth signals (i6) generated by sixth activations of the terminal members (TER'), to influence a connection angle of the respective vertical section, which connection angle is situated at the preparation line and relates to the specific shaping of the connecting surface/connecting lip against a tooth remnant in question.

11. Process for achieving, by means of input data (ID) representing a three-dimensional body (6) usable in the human body, e.g. tooth sleeve, dental bridge or other dental structure, output data (UD) which can be used for manufacturing purposes, which input and output data can be fed to or extracted from a computer installation (1), which exhibits a computer screen (5), operates with a program by means of which an adaptation, alteration or extension of the body can be simulated, and has terminal members (3), e.g. in the form of a key set, mouse, etc., by means of which the adaptation, alteration or extension is effected, characterized in that mathematical models, representing macro models, attributable to various forms of the tooth types, e.g. milk tooth, eye-tooth, etc., preparation forms, etc., are formulated by mathematical calculations or on experience-based grounds and are stored in a memory, preferably in assigned files, in that the respective macro model can be extracted by means of terminal or mouse activations on the computer installation so as to be representable on the computer screen, in that the respective representation of the respective macro model can be superimposed on a reading of a sleeve, tooth, preparation, etc., and in that, by means of the said superimposition function, an adaptation, alteration, extension to the said reading is achieved by means of the terminal members/mouse.

12. Process for achieving, by means of input data (ID) representing a three-dimensional body (6) usable in the human body, e.g. tooth sleeve, dental bridge or other dental structure, output data (UD) which can be used for manufacturing purposes, which input and output data can be fed to or extracted from a computer installation (1), which exhibits a computer screen (5), operates with a program by means of which an adaptation, alteration or extension of the body can be simulated, and has terminal members (3), e.g. in the form of a key set, mouse, etc., by means of which the adaptation, alteration or extension is effected, according to Patent Claim 11, characterized in that the content of data files for read data/shapes or shapes which have been calculated or acquired by experience are run together and represented together and with one or more macro models on the screen in order to permit the formulation of representations and the realization of output data of adapted, altered, extended body shapes or body variants, and in that, for example, files on a surface/inner surface and read wax-hood information are merged and run together with at least one macro model, which represents a mathematical model attributable to the form of tooth type, preparation, etc., for the formulation of the shape/product/data/processing coordinates in question, the formulation requiring the handiwork skills of the dental technician/dentist, and the computer installation also permitting complicated formulation and preferably facilitating routine work.

13. Device for implementing the process according to Claim 1, 11 or 12 for achieving, by means of input data (ID) representing a three-dimensional body usable in the human body, output data (UD), which can be used for manufacturing purposes, e.g. processing coordinates, representing an altered or extended body variant and utilizing a computer installation (1) comprising screen (5), program and terminal members, characterized in that it forms a station (ST), which can be set up at the practice of a dentist/dental technician or equivalent professional category and by means of which the body variant can be simulated by means of the program operating with a CADD-function, in that the station comprises memory storage cells (DF1) for the input data, and in that the CADD-function, in order to reproduce the surface of the body on

the screen and in order to permit alteration or extension of the latter according to the body variant, operates with a number of vertical sections, extending through the centre axis of the body, of the body contour or body variant contour (24, 24'), the vertical sections being able to be represented on the screen one at a time, and attachable alterations or extensions related to the alteration or extension of the body variant relative to the body being able to be formulated on the screen, and in that the said memory cells (DF1), or additional memory cells (DF2), are arranged to receive and store data attributable to the altered or extended vertical sections/contours, which data form or serve as a basis for the said output data.

14. Device according to Patent Claim 11, characterized in that the input data (ID) are realized by means of a scanning device (13), which comprises a spherical front part/probe (16), and in that the respective vertical section/contour can be represented with the aid of a surface model which can be worked out from the movements of the probe in the system of coordinates (2) of the scanning device, preferably comprising a polar system of coordinates.

Fig.1

Fig.2

Fig.3

Fig.4

Fig.5

Fig. 6

Fig. 7

Fig. 16

13

Fig. 8

28
29
24'
6a"
27

Fig. 9

28
30
28a
27

Fig. 10

27
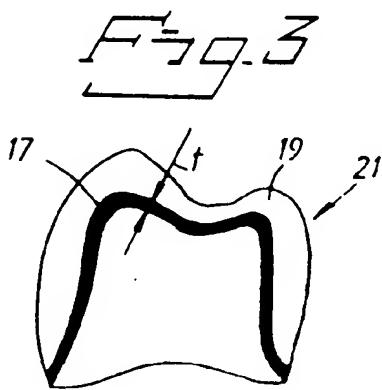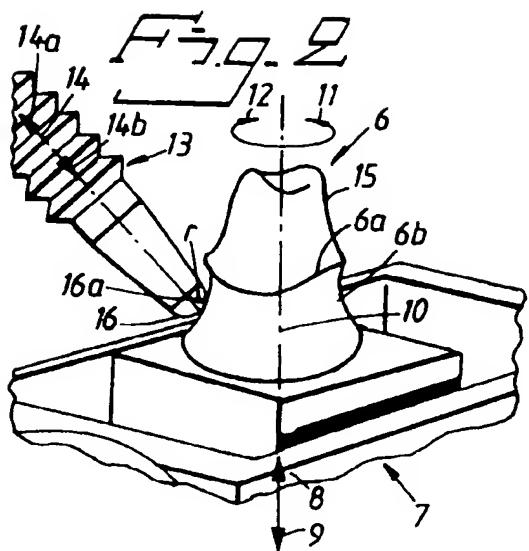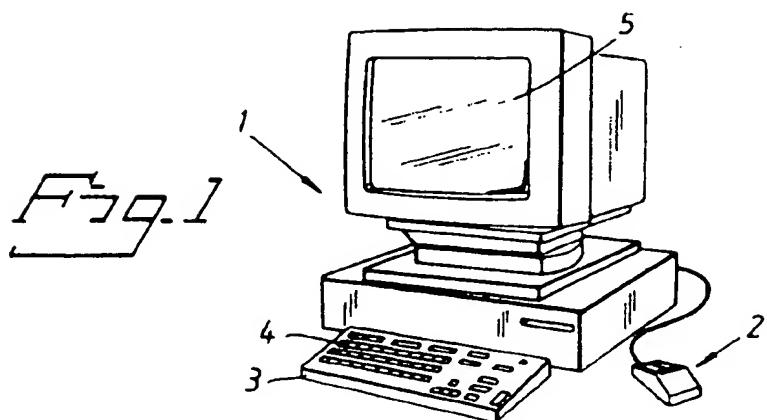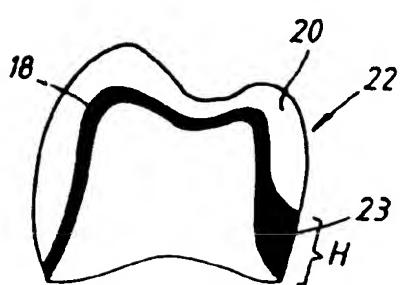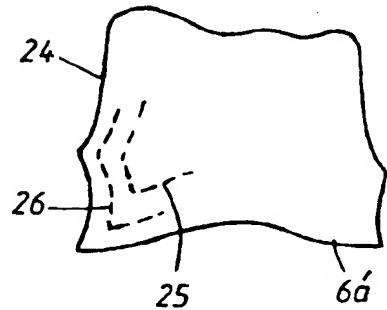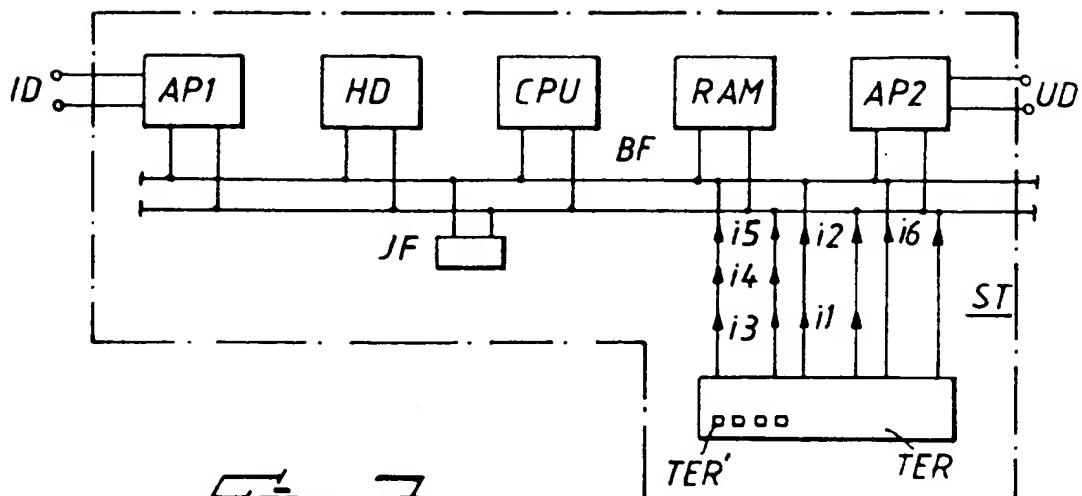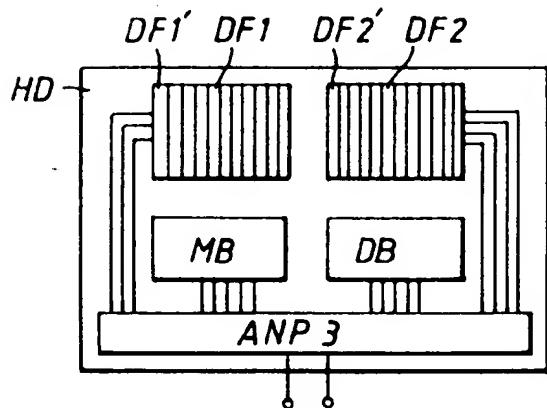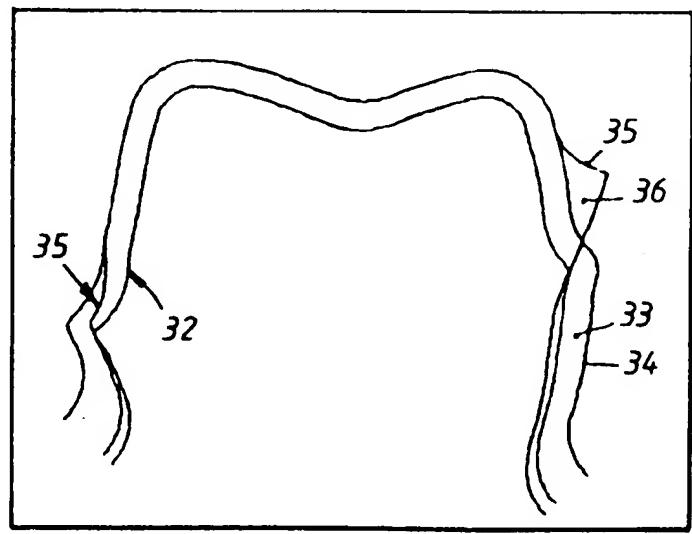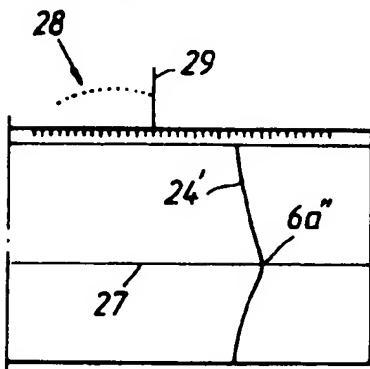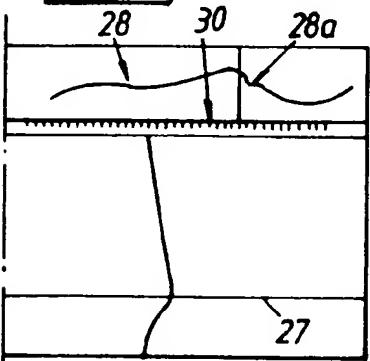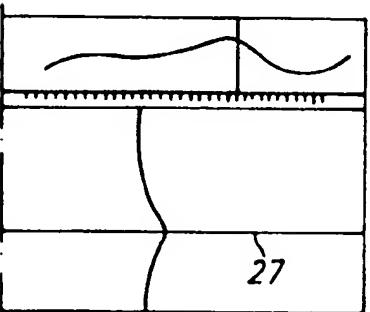
Fig. 11

SETTINGS

••••••••••••••••••••••••••••••	•••••
••••••••••••••••••••••••••••••	•••••
SHELL THICKNESS (•••)	400
••••••••••••••••••••••••••••••	•••••
••••••••••••••••••••••••••••••	•••••
•••••••••••••••••••••••••••••••▲▲▲	•••••
BORDER LINE ANGLE	0

Fig. 12

t'
31

Fig. 13, 14, 15

31'
31a
31b
0°

31'
31a'
31b'
20°

31'
31a"
31b"
40°
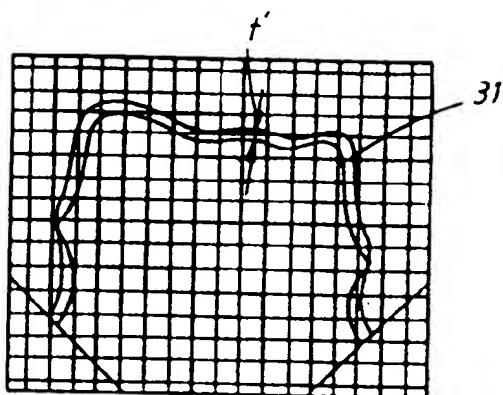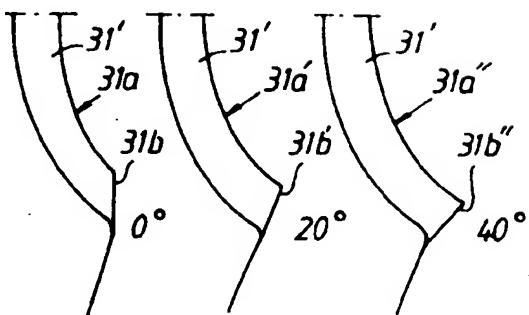
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EUROPEAN SEARCH REPORT

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TECHNICAL FIELDS
SEARCHED (Int. Cl.5)

A61C
G05B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
STOCKHOLM	18 October 1994	JACK HEDLUND

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